Next Generation Wi-Fi: 6 GHz is on the Horizon

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The push to open the 6 GHz band (5.925-7.125 GHz) to unlicensed use is being driven by explosive growth in consumers' data needs, particularly from applications such as video streaming and video on-demand. The demand for data is being further bolstered by social media applications, audio platforms, and smart home devices. In addition, new and burgeoning applications such as virtual reality (VR) and augmented reality (AR) will continue to drive significant data demand into the future.

But what exactly is the 6 GHz band? What is it currently used for, and how does it benefit consumers? Perhaps more importantly, how will the emergence of Wi-Fi 6 – whose certification program from the Wi-Fi Alliance® that launched in September 2019—affect the use and performance of the 6 GHz band? This article aims to answer these questions.

Wi-Fi 6 GHz Band – State of the Union

The 6 GHz band is intended to significantly bolster available bandwidth when compared to existing Wi-Fi, improving both the quality of service and supporting consumers' insatiable demand for more data. The new spectrum represents a bandwidth increase of over 150 percent compared to the 2.4 GHz and 5 GHz spectrum used today.

The Wi-Fi Alliance, tasked with selecting features from the 802.11ax standard and certifying interoperable 802.11ax products, is branding these new 11ax devices as "Wi-Fi CERTIFIED 6™". Although Wi-Fi 6 devices can operate presently in either 2.4 or 5 GHz bands – or 6 GHz in the future – the IEEE 802.11 working group has stipulated that only Wi-Fi 6 devices can be permitted to operate in the 6 GHz band. To avoid confusion, the Wi-Fi Alliance has recently branded Wi-Fi 6 devices operating in the 6 GHz band as "Wi-Fi 6E". Offloading slower Wi-Fi speeds to the 2.4 GHz and 5 GHz bands should ensure faster, higher-quality throughput for Wi-Fi 6E devices operating in the 6 GHz band.

In the U.S., FCC commissioners and FCC Chairman Ajit Pai voted unanimously in October 2018 to release up to 1.2 GHz more Wi-Fi (unlicensed) spectrum in and around the 6 GHz band. Since then, the central debate around 6 GHz is whether new Wi-Fi operations in the band could interfere with its existing users, which include public safety, utilities support, and wireless backhaul. As such, the use

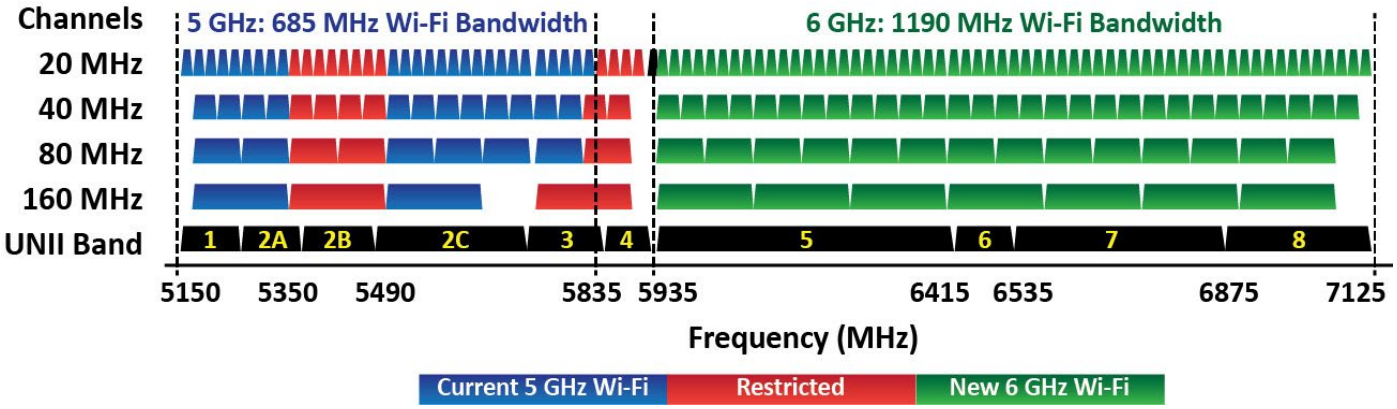

Figure 1. The U.S. FCC's proposed division of the 6 GHz band into four sub-bands

and operating rules of the 6 GHz band have yet to be fully ratified by the FCC.

Chairman Pai has acknowledged that the release of 1200 MHz within the 6 GHz band for unlicensed Wi-Fi use is a historic event: a large chunk of bandwidth, free, for public consumption. The FCC's current plan is to divide the 6 GHz band into four sub-bands (Fig. 1): U-NII-5 (5.925-6.425 GHz), U-NII-6 (6.425-6.525 GHz), U-NII-7 (6.525-6.875 GHz), and U-NII-8 (6.875-7.125 GHz).

The FCC also plans to regulate unlicensed use in the 6 GHz band. For access points, they have recommended a two-class approach, differentiating between low-power indoor access points operating at 24 dBm, and standard-power access point devices operating at 30 dBm. Standard-power access points will be required to use a database lookup scheme before transmitting to avoid causing interference with fixed wireless incumbents. Low-power indoor access points will only be permitted to operate indoors and will not be required to use the database lookup scheme.

In addition, the FCC has proposed that client devices be permitted to operate in the 6 GHz band, but that their power be limited to 18 dBm to avoid interfering with fixed wireless incumbents in the band. Industry groups have requested an additional class to be added: a very low power access point operating at 14 dBm. This class of device would be used as a mobile hotspot, for example.

The greatest opportunity for component and product designers presented by the 6 GHz band also represents one of its most significant challenges – the very introduction of a third 6 GHz radio, in addition to the 2.4 GHz and 5 GHz radios currently being used for Wi-Fi applications. A third radio is good news for semiconductor suppliers, as it means more content opportunity (new radios, filters, power amplifiers), and consumer product makers as they create fresh devices that will take advantage of the new spectrum. However, when you concurrently operate 2.4 GHz, 5 GHz, and 6 GHz radios in the same product such as a router, the system complexity increases significantly. Additionally, thermal challenges escalate as industrial designs for

Parameter			Wi-Fi 5 (802.11 ac)	Wi-Fi 6 (802.11 ax)	Wi-Fi 6E (802.11 ax)	802.11 be[3]
Frequency			5 GHz	2.4 and 5 GHz	6 GHz[2]	2.4, 5 and 6 GHz
Number of Channels[1]	Channel Bandwidth (MHz)	20	25	28	59	87
		40	12	13	29	42
		80	6	6	14	20
		160	2	2	7	9
		320	0	0	0	4
Access			OFDM	OFDMA	OFDMA	OFDMA
Antennas			MU-MIMO (4 x 4)	MU-MIMO (8 x 8)	MU-MIMO (8 x 8)	MU-MIMO (16x16)
Modulation			256 QAM	1024 QAM	1024 QAM	1024 QAM
Maximum data rate			3.5 Gb/s	9.6 Gb/s	9.6 Gb/s	38.4 Gb/s
Maximum users/AP			4	8	8	16

1. Non-overlapping channels
2. Best Estimate: channelization has not been finalized
3. Speculative; standard is still in early stages of development.

Table 1. Comparing Wi-Fi5, Wi-Fi6, and 802.11be Standards

consumer electronics are trending toward smaller, more compact designs.

6 GHz Band Regulation in the U.S.

Skyworks' experts are working in partnership with other members of the Wi-Fi Alliance, providing guidance in support of comments on FCC proceedings regarding the 6 GHz band.

So far, the most significant enhancements of Wi-Fi 6 and Wi-Fi 6E (over Wi-Fi 5, or 802.11ac, implemented in 2014) are the introduction of Orthogonal Frequency Division Multiple Access (OFDMA) and the enhancement of multi-user, multiple input multiple output (MU-MIMO).

OFDMA is a modulation scheme intended to reduce latency, boost capacity, and improve efficiency by allowing as many as 30 users to simultaneously share a channel. It also borrows a page from the cellular world and uses a scheduler to tell users exactly when they should transmit their data to avoid collisions.

Introduced in 2015, MU-MIMO only worked for outgoing signals from the router (downlink); Wi-Fi 6 will allow routers to handle incoming signals from multiple devices (uplink), as well.

To differentiate between the two, and understand how they complement each other, picture data transfer as cars on a highway. OFDMA, aimed mostly at boosting low-bandwidth applications, raises the highway's speed limit and increases speed by reducing collisions; MU-MIMO, aimed mainly at high-bandwidth applications, would be represented as additional lanes being added to the highway.

What does that mean in terms of speed? Wi-Fi 6 is over two-and-a-half times faster than Wi-Fi 5 and will offer better performance for connected devices (Table 1). FCC Chairman Pai told guests at the Wi-Fi World Congress in May 2019 that the economic value created by Wi-Fi in the U.S. is projected to double by 2023—reaching nearly $1 trillion.

That said, FCC regulators must address several yet-to-be-decided considerations that could deeply impact how the 6 GHz band is deployed. These include maximum allowed transmit power and automated frequency coordination (AFC). AFC is a database lookup mechanism intended to protect incumbent users within the 6 GHz spectrum.

What AFC means for users is that the FCC is seeking to impose different sets of rules on each of the 6 GHz sub-bands. While the details are not set in stone, currently, U-NII-6 and U-NII-8 (Fig. 1) have similar rule sets that make them available for usage only for indoor applications, with output power limits of 24 dBm (250mW) conducted and 30 dBm (1W) radiated. For U-NII-5 and U-NII-7, AFC will be required whether it's an indoor or outdoor application. Output power limits in these bands will be 30dBm conducted and 36dBm radiated.

Objectively speaking, such a database is a positive development to preserve the integrity of the incumbent users of the 6 GHz spectrum. However, it may take several years to develop, test, and certify before AFC is ready for consumer and enterprise class products. Implementing rules prior to AFC deployment with fewer restrictions and higher transmit powers will lead to an improved consumer experience, enabling them to better leverage this new available bandwidth.

Still, it's not yet been confirmed who will create this database, or when it is going to become operational, leading to potential delays in use of the U-NII-5 and U-NII-7 bands, which are estimated to account for up to three-quarters of usable frequency in the 6 GHz band. The FCC is expected to address these concerns in a Report And Order (R&O) document estimated to be available in early 2020.

Conclusions

Release of the 6 GHz band for unlicensed Wi-Fi use is an unprecedented move by the FCC – 1200 MHz of spectrum available for public consumption. The benefits of this extended bandwidth have the potential to be tremendous. Not only will it be a boon for consumers' ever-growing need for more data, but it has the potential to enable new applications which have yet to be imagined. Benefits could range from increased efficiency, workforce productivity, and new market opportunities – driving economic growth and employment possibilities.

However, to best serve both end users and product developers, it is important that there be no delays in the FCC's schedule, since the ripple effects of delays impact both product developers and consumers. Additionally, it is hoped that regulators will align their stance on automated

frequency coordination, so the AFC requirements provide a positive experience for consumers' indoor and outdoor applications. It is vital that early deployments, prior to AFC availability, be allowed to transmit at high enough output powers to provide strong quality of service. Tangible benefits for first movers in the new spectrum certainly exist given the market opportunity being driven by consumer demand for ever-increasing data rates.

The usefulness and utility of the 6 GHz band will be immediately available once regulations are defined. Adoption will not be hindered by limited rollouts or incomplete infrastructure. Indeed, 6 GHz test gear is already available and the first 6 GHz Wi-Fi-capable smartphones will be available in 2020.

As a leader in all major wireless technologies, Skyworks has built its expertise across successive Wi-Fi standards and has developed solutions that address the unique challenges and complexities of each generation. Skyworks is prepared for this next evolution of Wi-Fi with high volume production of its suite of integrated front-end semiconductor solutions to ensure customers are poised to capture this significant market opportunity and the economic prosperity associated with Connecting Everyone and Everything, All the Time.

Take advantage of our knowledge by visiting our website for information about our latest Wi-Fi solutions, or contact Skyworks directly. To receive product updates on Wi-Fi 6 and Wi-Fi 6E, sign up for Skyworks' eNewsletter.

About The Author

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For more information about our solutions, please visit us at www.skyworksinc.com